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ABSTRACT

The paper describes new software and special input devices to allow physically impaired children to utilize the graphic capabilities of personal computers. Special input devices for computer graphics access--the voice recognition card, the single switch, or the mouse emulator--can be used either singly or in combination by the disabled to control graphics software. The disabled who have no problem in speech production sounds can use the speech recognition system; the disabled who have phonation problems may use a single switch activated by simple push actions coupled with suitable software. Newly developed by the authors is the mouse emulator which allows control of both graphic and communication software by means of simpler movements than those required to use a standard mouse. Two push-buttons allow either selection of objects displayed on a screen or activation of a function related to the chosen object. The pointer controller allows the user to move objects around the screen. Both standard and specially developed graphic software can be used. The mouse emulator can also serve as a pointer communication aid for nonspeaking disabled individuals. A special multichannel input interface was developed by the authors to allow motor disabled persons to produce three-dimensional pictures on the screen. This interface is described in some detail. (DB)

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GRAPHICS WITH SPECIAL INTERFACES FOR DISABLED PEOPLE

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ABSTRACT

Some physically impaired persons are unable to use standard drawing tools (pencil, eraser, paper, etc.). An effective way to deal with the problem is to create a graphic environment with features that motor disabled can control. A motor disabled person can use some commercial graphic program by means the special interface (working as mouse emulator), that we developed. Special software oriented to provide mentally impaired children with some computer graphic capabilities can be developed. This software can be useful when the commercial available software is unsuitable. We are developing special software that provide physically impaired children with the capability of graphical represention of three-dimensional scenes. This software can be controlled by means some different special input interface including a speech recognition system.

1. INTRODUCTION

The growth and the spreading of the information technology affect profoundly and favorably all the sectors of the human life. It is common knowledge that personal computers (PC) can notably increase the efficiency and the capabilities of the persons without physical, sensorial, and mental problems (non disabled people). In general, one cannot say the same for disabled people (DP). Personal computers and the software that runs on them have not been designed for DP. Hence, the PC can create new technological barriers for these people.

On the other hand, many advantages can be taken using a PC as a main block in communication systems for DP. It is possible to obtain simplifications in many kind of design and to concentrate our attention on the special interfaces and on communication, education, and rehabilitation software.

By using special interfaces and software we tray to allow DP the access to the possibilities offered from the PC.

Many results were obtained using this approach and many aids are available concerning different needs as communication, control,

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computer access for DP (blind, deaf, physically handicapped, non speaking, etc.) [1, 2].

A very important field, of the general communication problem, is the graphic interaction. It is known that some groups of DP find insurmountable obstacles with the computer keyboard access. The problem becomes very hard when the interaction is performed by mouse or by tracking ball. Some of motor disabled persons (MDPs) are unable to produce fine shift movements required for these input devices. This problem implicates, in many cases, no access to standard writing and drawing tools (pencil, eraser, brush, paper etc.). This impediment drastically reduces the disabled child's world and school integration, impairing the cognitive and psychological development.

The need to obtain instruments allowing to DP same degree of graphic production came out from the previous considerations. In the following some approach to computer aided drawing system for MDP is sketched. Three special input devices can be used for the computer access: a single switch, a mouse emulator, and a voice recognition card. MDP can control software using one of the previous devices in combination or one at time.

2. SPECIAL INPUT FOR GRAPHICS

It is known that mouse, tracking ball, graphic tablet are popular input devices for the user-computer interaction in graphic environment. Unfortunately all of the previous devices are not accessible for MDP. The problem is to find alternative input devices to implement special MDP-computer interfaces.

In some case we have MDP which have no problem in speech production sounds. For these users an efficient input device can be a speech recognition system. Some inexpensive systems are available. In general these devices operate in speaker dependent mode, and are able to recognize isolated words (typically: 100-200 expressions, 2-3 s of duration each one). One of these devices can be used with special interaction software to implement an efficient MDP-computer interface.

When the MDP has problems in phonation, different approach must be implemented. The simplest input device is a single switch activated by simple push actions that MDP can produce using parts of the body (hands, fists, elbows, etc.). Some different implementation are available depending on the residual skill of the MDP. A single switch produces a very poor information (one bit) and it needs suitable software to build an MDP-computer interface system.

In our Institute a special input device, designated Mouse Emulator, has been developed and patented [3]. This device allows the MDP to control both graphic and communication software by means

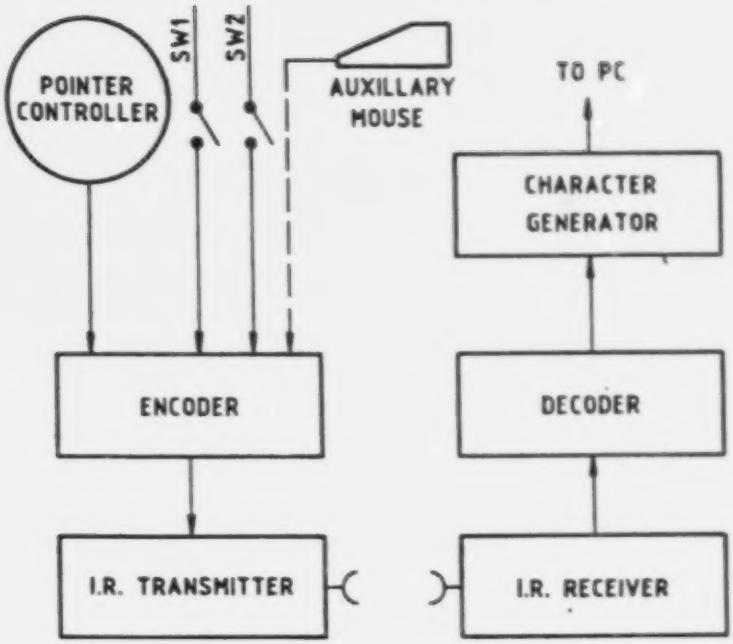


Fig. 1. Block diagram of the Mouse Emulator

of simpler movements than those required to use a standard mouse. A block diagram of the device is shown in Fig. 1.

The device includes two suitably shaped push-buttons. The first one (monostable switch) , allows selection between objects displayed on the personal computer screen (icons, alphanumeric characters, special symbols, etc.). The second one (bistable switch), activates the function related to the chosen object. The same function can be disabled by the first push-button.

The physical shape of the pointer controller is a flat disk (diameter of 200 mm, thickness 15 mm). Four internal switches can be activated (singly or in pair), depending on the disk zone pushed by the user. The activation of a single switch determines one of main directions (1=North, 2=East, 3=South, 4=West), while The activation of a pairs of switches determines four intermediate directions (1-2=Northwest, 2-3=Southeast, 3-4=Southwest, 4-1=Northwest), for a total of eight different directions.

By means pointer controller one can control the x-y coordinates of the objects on the screen, thus allowing shifting in eight equispatial directions and facilitating the movements of the ob-

jects around the screen.

Since different users have different reaction times, the shift rate (pointer rate) can be adjusted by a control knob located on the characters generator that send signals to the PC with the same protocol used by standard mouse. This feature allows to match shift speed to users skill.

This part of device must fit the users residual ability. An optimum method of customizing this part can be developed. The cylindrical shape can be considered an example of implementation. However, the chosen approach, to transform fine shift movements along the plane into simple push actions requiring considerably less coordination, remains effective.

The system has an auxiliary port where a standard input device (e.g. standard mouse or joy-stick) can be connected. This feature allows the teacher or assistant to intervene with examples or suggestions, that are especially useful during the training period.

The pointer controller and the characters generator are connected together by an infrared link allowing up three meters distance between pointer controller and PC, this to give MDP greater freedom of movement. This feature needs to encode the ten commands required (eight for the different direction and two for bistable and monostable switch) because the infrared channel works with a serial protocol. Consequently it is necessary a decoding of the signals at level of character generator. A block diagram of the device is shown in Fig 1.

3. GRAPHIC SOFTWARE

Many graphics programs are available for MS-DOS. PC-Paint by Mouse System, Gem-Draw by Digital Research, Dr-Halo by Media Cybernetics, are among the most popular. All these programs implicate mouse input interaction and enables the user to draw, edit, print, and color pictures created from lines, boxes, polygons, circles, etc. selected from a menu by means the Mouse Emulator. A MDP will be able to produce most of the school graphics that could not produce otherwise.

Mentally-impaired children require special software that is even simpler to operate than existing programs. To meet some needs we are developing customized programs, in collaboration with psychologists and teachers. In one simplified program, drawing with colored pencil is simulated by selecting and erasing lines. Another program simulates a building blocks toy [5].

4. MOUSE EMULATOR AS POINTER DEVICE

In the case of nonspeaking disabled persons, the mouse emulator

can be used in conjunction with other computerized communication aids that help to select alphanumeric or special symbols. The develop of a system that allows to build different types of messages is in progress. By means the mouse emulator it is possible to pick Blissymbols [4] and, to link together them, it is possible to build strings of ASCII characters. These strings are transferred by RS-232 serial channel to the speech synthesizer. In our experiments we use an Italian speech synthesizer designed in our Institute.

5. THREE-DIMENSIONAL GRAPHICS

We propose a system that allows MDP to produce three-dimensional pictures on the screen. The software, that we wrote, makes possible to build, to editing, to store, scenes and to show them according to three main representations: orthogonal projections, perspective, and axonometric projections.

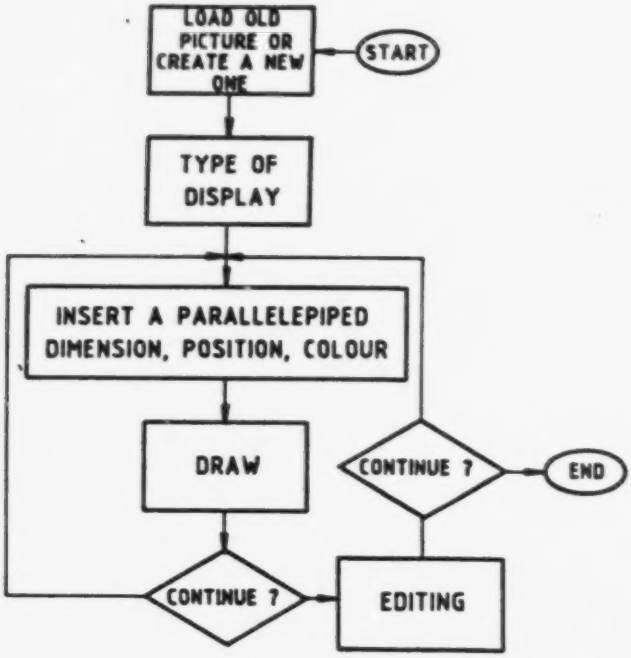


Fig. 2: Block diagram of the software

To allow the MDP to control the graphic features we implemented a special multichannel input interface (MII). Using the MII a motor disable can interact with the program and manage three-dimensional scenes on the screen.

The MII is building up by three different input devices: a single switch, a keyboard, and a speech recognition system. All three devices can operate one at time or at the same time. This fact allows fitting on several kind of residual skill and allows a teacher to control the graphic software in parallel. By this method it is possible, for a teacher, to enter suggestion, correction etc. The system includes a digital speech synthesizer to strengthen the command requests. The software allows to build complex pictures locating parallelepipeda, of wished sizes an color, in the Cartesian space.

The program stores every new parallelepiped on the disk, recording its absolute coordinates in a previously named file. So the scene can be shown later with each of three display modes. The user can modify the picture entering in a simple editor program and delete the chosen elements. At the end of the editing he can decide to save the picture in the old file or in a new one (in this case the old picture is definitely lost).

The screen is divided in three windows (Figure 3): on the larger one the building picture appears. The program displays its question in the window at the bottom of the screen and a table of alphanumeric characters and special symbols appear in the third window. Color choice can greatly affect the user's reactivity.

MDP constructs needed command words, using one or more of the three integrated channels: single switch, voice recognition system, and keyboard.

A scanning system allows MDP to select characters from the table displayed on the screen. The table is scanned first by rows an then by columns: activating the switch user can stop scanning row an then column, so he selects a character.

When a command string is finished, it is sent to the program selecting a special character. User can delete a character or all the string selected using special symbols. Furthermore the table contains a reserved zone to display which cannel is active at the moment.

When a question requires only a restricted number of characters to construct the answer, scanning is limited to the needed characters, reducing the overall time needed to build up the scene.

The second way to build up commands uses a voice recognizer to carry out the selection of the characters. To select the willed character the user has simply to pronounce the words digit by digit.

The used voice recognizer system is RA201/PC from Infovox. It is implemented as a single board to plug into a slot of the internal

bus of a IBM compatible PC. It uses the same microprocessor of the host PC.

This device can recognize up to 167 words or short expression up to 2.5 s long, and it is speaker dependent. Thus the user has to execute a training before using RA201. During the training the user builds up a personal vocabulary that will be used by the recognizer to "understand" spoken words.

It is possible to limit the recognition to previously selected groups of words among the vocabulary ones, like in the scanning

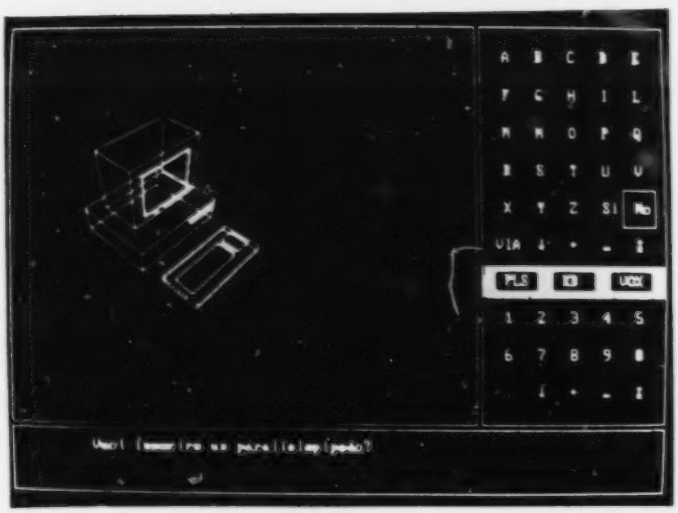
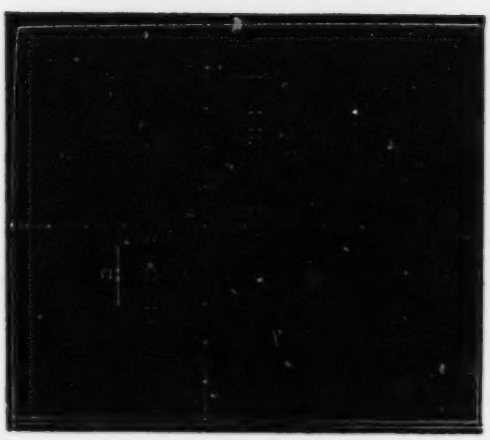
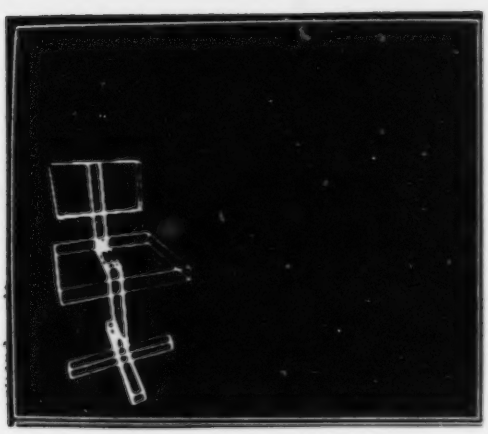


Fig. 3: General view of the screen, and exaples of Orthogonal Projection and Perspective.





method, obtaining a faster time response and an higher error immunity.

The vocabulary can comprehend the same characters of the table, or only a group among the more frequently used ones.

The third method consists in a keyboard used in the normal way.

All three channels can be used alone or operate together in any sort of configuration to fit better the residual skill of a MDP and to allow a non disable person to intervene efficiently. Moreover, the contemporary use of more channels can improve speed and can reduce the effort needed to use this graphic tool.

The main hardware unit used to implement this graphic tool is a IBM compatible PC, containing an EGA (Enhanced Graphic Adapter) board, the RA201 board and a voice synthesizer.

In the initializing phase, the program sets the parameters like selection speed, MII channel activation, personal vocabulary and colors to their initial value. Then the program acquires and processes the data supplied by the user to draw the picture. Furthermore the program implements the software part of the MII carrying out the table scanning and controlling "in parallel" the three possible inputs.

The graphic program sends commands to the voice recognizer by means of a software interrupt. The routine used to send commands recognizer, constitute a custom-built library.

The programming language used is the QuickBASIC (Microsoft). The program length corresponds to 1700 lines for an amount of memory of about 70 kbytes after compilation plus 14 kbytes occupied by the library.

The QuickBASIC programming language has been chosen for its good graphic features and speed joined with a large choice of software structures that allow to write effective and well readable programs. Some examples of pictures obtained from the system are shown in Fig. 3.

6. CONCLUSION

We suggested same tools to allow impaired people to use the same facilities offered from the computer graphic to the normal persons. Furthermore we gave prominence to the role played from the new computer technology to overcame same communication and learning difficulties of disabled people, related to the graphic expression.

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